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Center

Integrated Project: Bering Sea Project

Mike Sigler

Ecosystem Science Review
Juneau, Alaska
May 2-6, 2016

Bering Sea Project

Bering **E**cosystem **St**udy (BEST) +
Bering **S**ea **I**ntegrated **E**cosystem **R**esearch **P**rogram (BSIERP)

North Pacific Research Board
Board of Directors meeting
Anchorage, Alaska
April 30, 2014

Mike Sigler (NOAA)
(on behalf of the larger program)

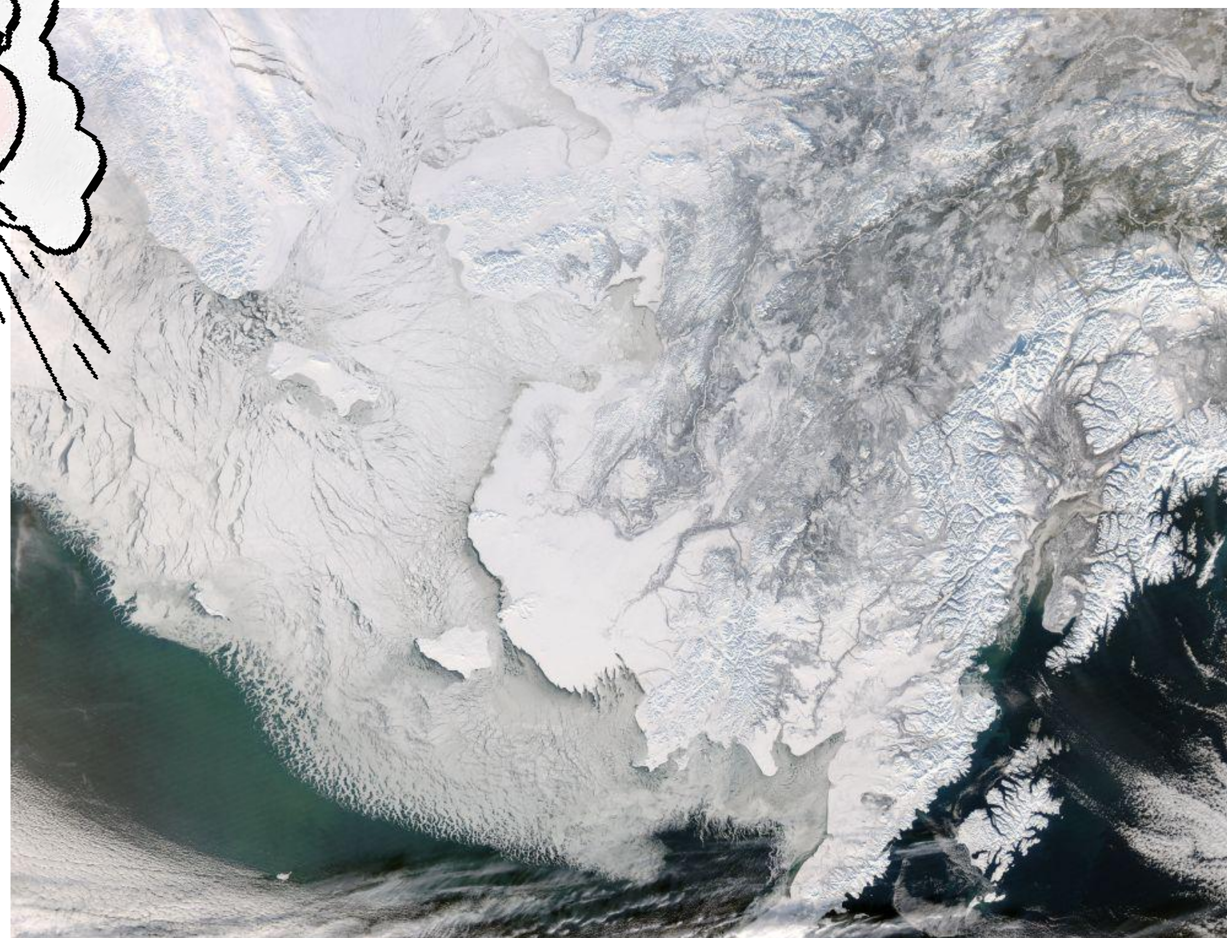
Program scope and chronology

- **2007 – 2010** Field Work
- **2011 – 2013** Synthesis
- **24,205** person-days of fieldwork
- **176** publications to date

Outline

- Prologue: Seasonal ice and the cold pool
- Chapter 1: Why did pollock abundance decline then rebound in the last decade?
- Chapter 2: Location matters for fur seals and fishermen
- Chapter 3: The eastern Bering Sea in the future
- The benefits of an integrated program

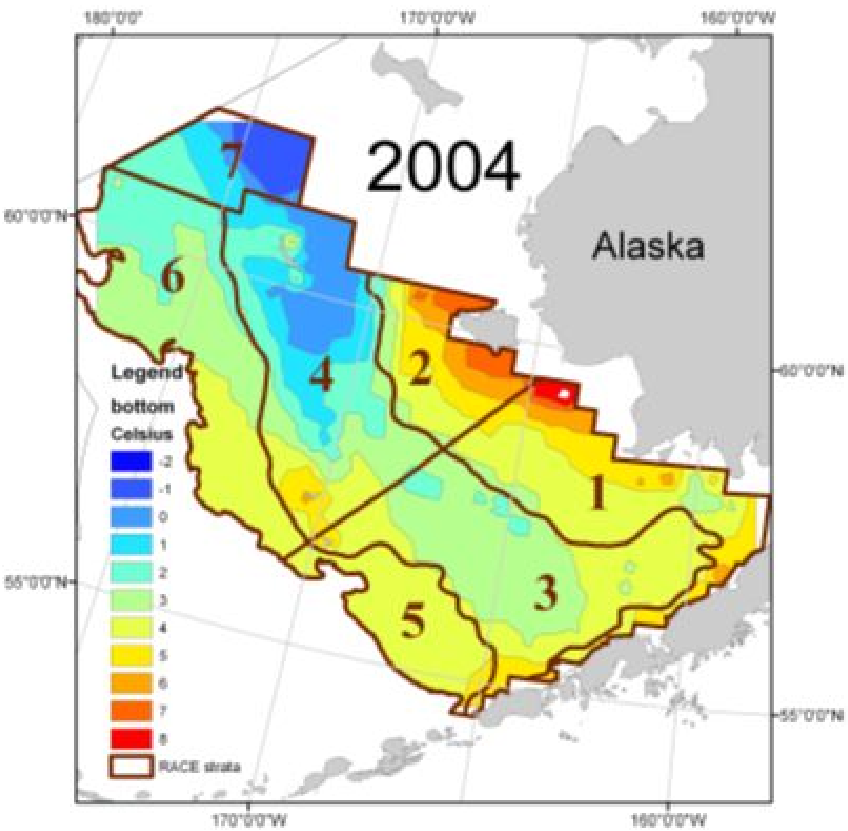
Prologue: Icy winters occur when winds are from the north and Arctic in origin



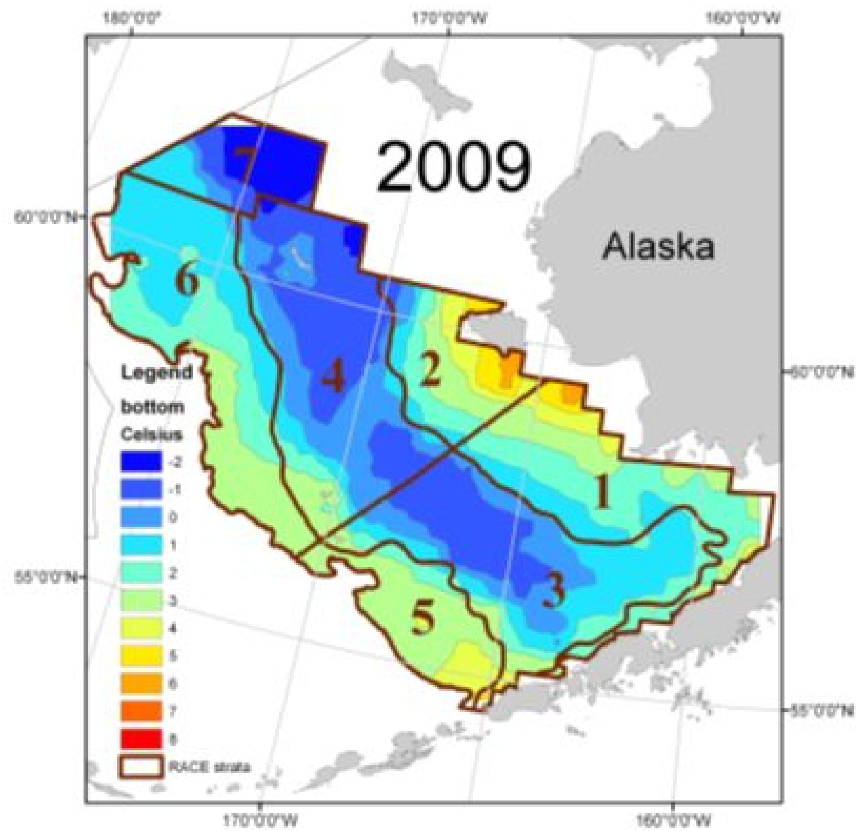
Satellite image climate.gov, wind image jacksmumontherun.wordpress.com

Icy winters increase the size of the 'cold pool' (<2 °C)

WARM YEAR



COLD YEAR



Lauth

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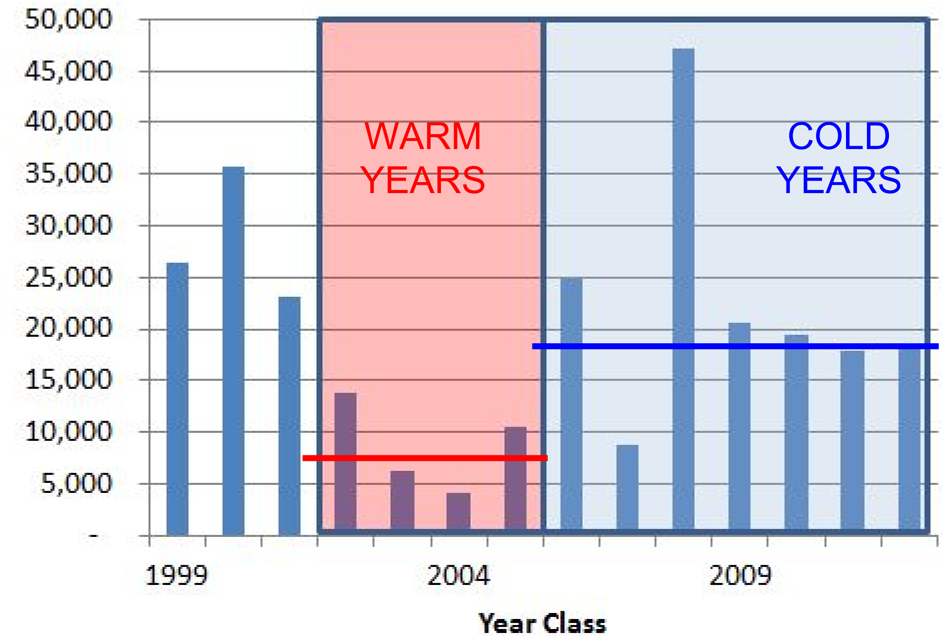
Chapter 1

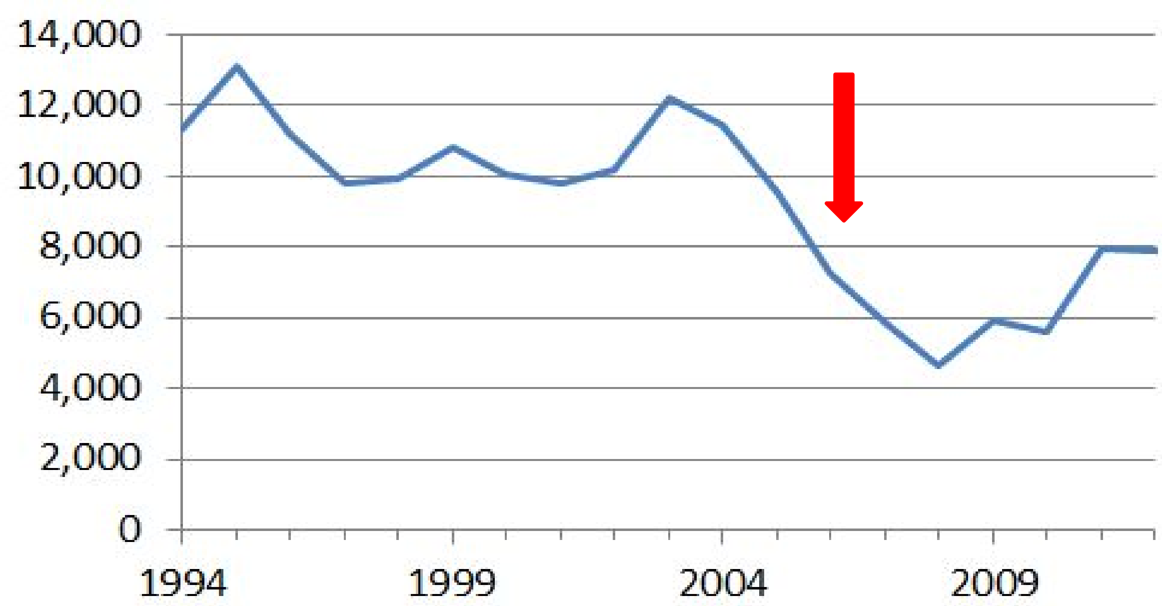
EXPLAIN THIS:

Walleye pollock abundance dramatically fell in the early 2000’s, leading to a 40% drop in the quota for the largest single fishery in the US, and then rebounded.

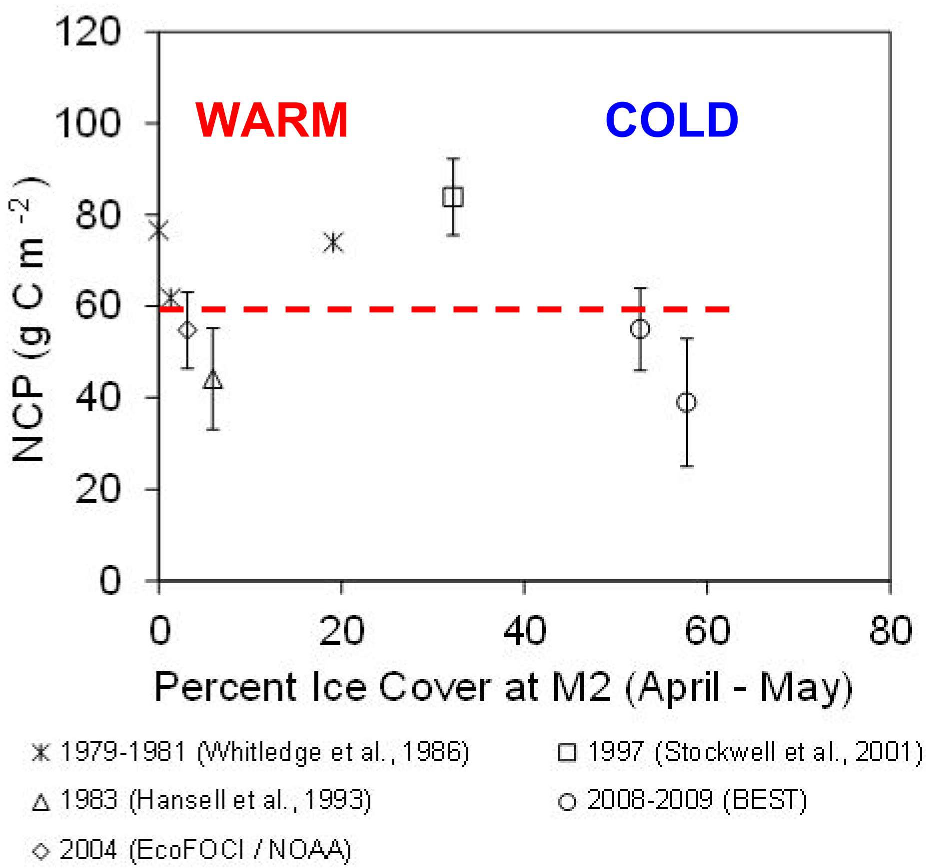
Age-1 number (millions)



Age-3+ Biomass (thousands t)



The amount of primary production available for copepods and krill is similar in warm and cold years

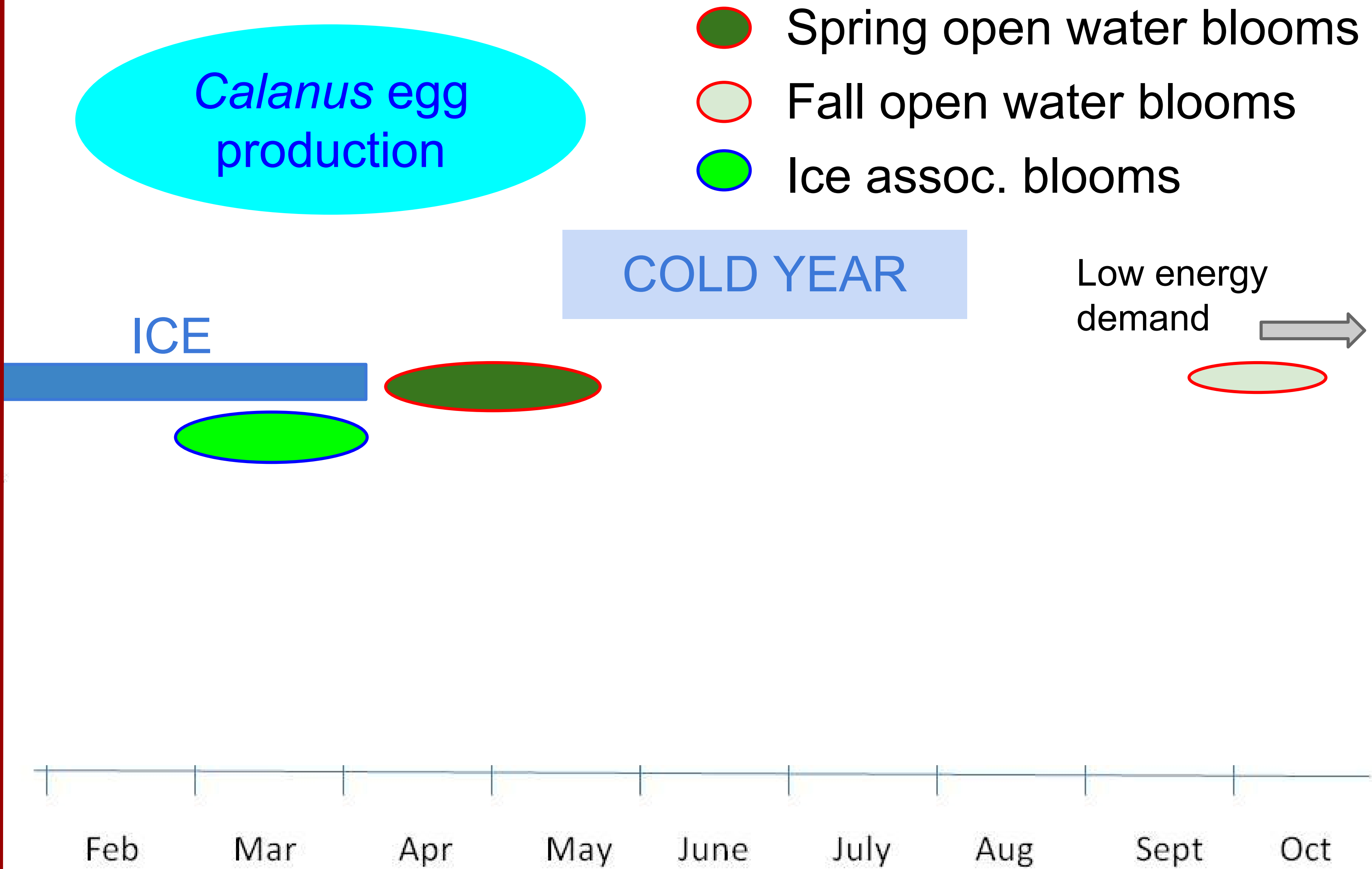


… and does not appear to limit production of copepod and krill, which are prey for age-0 pollock

Mordy, Cokelet, Ladd, Menzia, Proctor, Stabeno, Wisegarver

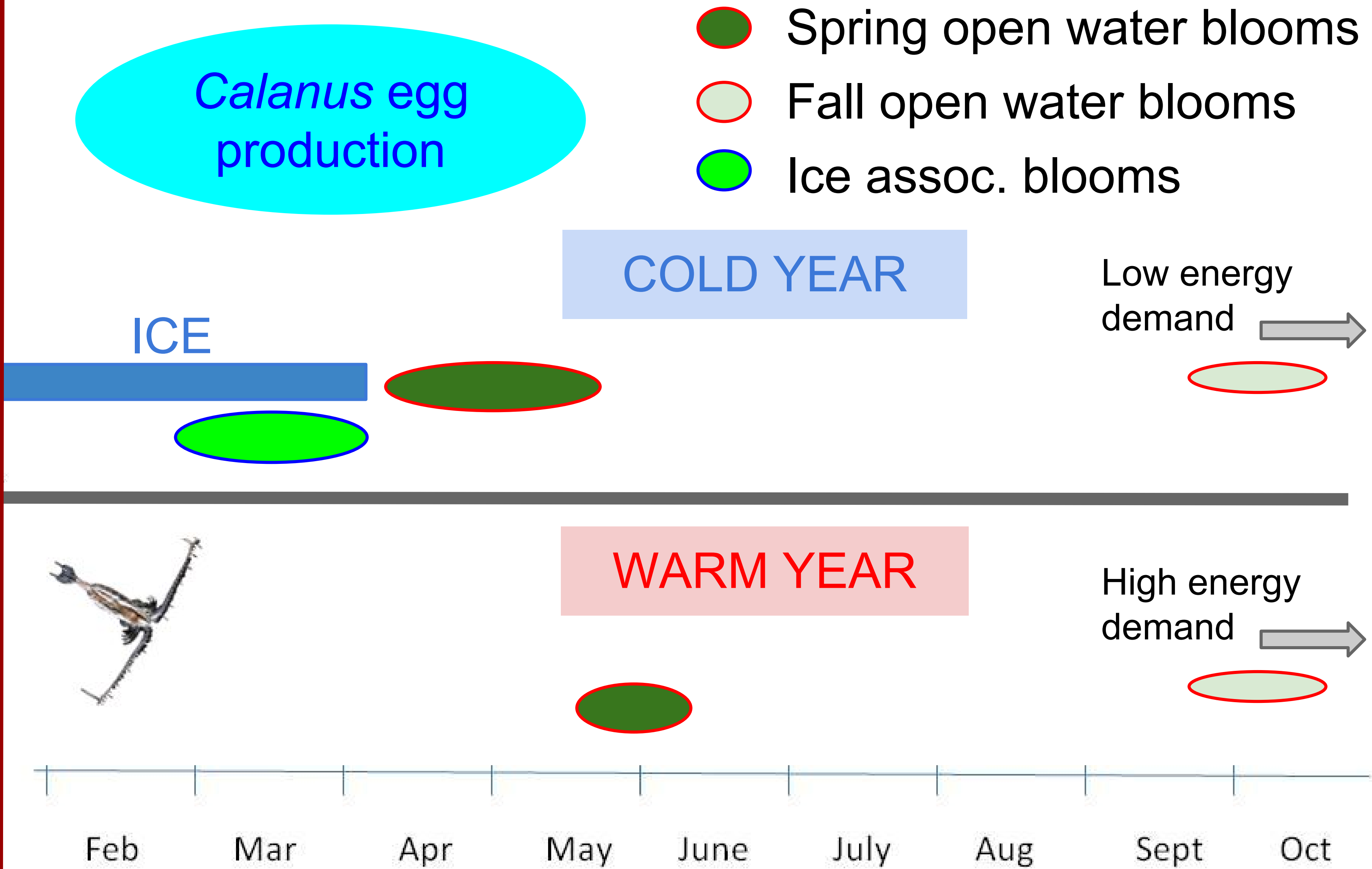
Campbell, Ashjian, Lessard, Liu, Zhai, Zeeman, Eisner, Gann, Mordy, Moran, Lomas, Gibson

Bloom timing matches copepod egg production in cold years



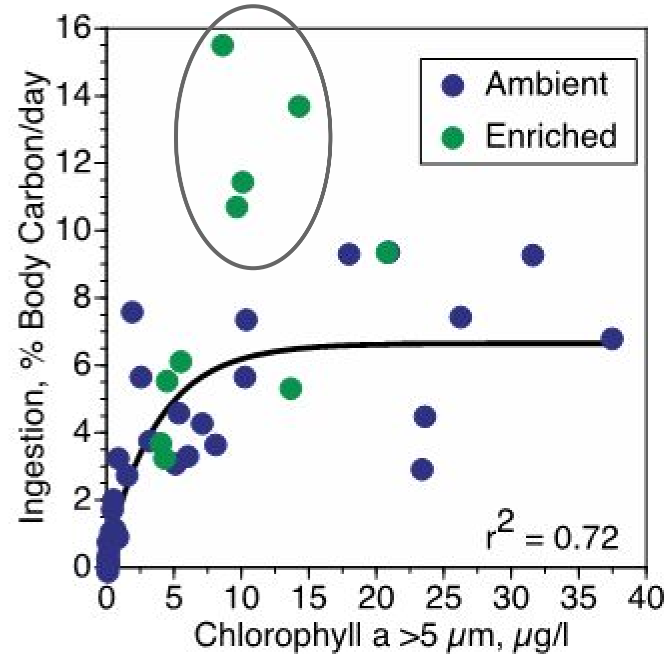
Baier and Napp, Hunt et al, Coyle et al

Bloom timing matches copepod egg production in cold years but not warm years



Baier and Napp, Hunt et al, Coyle et al, Sigler et al

Ice algae likely enhances copepod reproduction

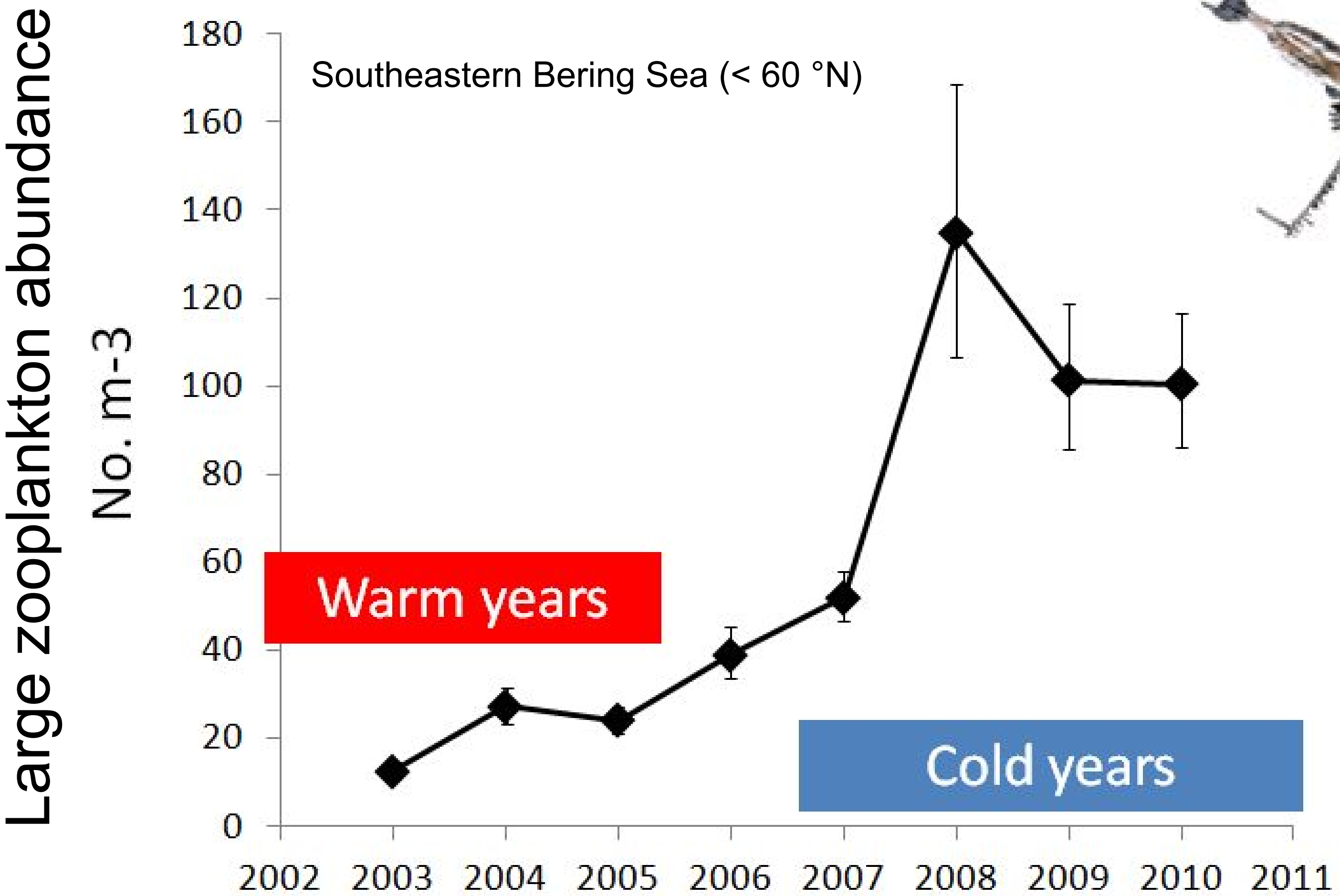


Gradinger, Bluhm, Iken, Weems

Higher ingestion rate when feeding on ice algae than water column phytoplankton

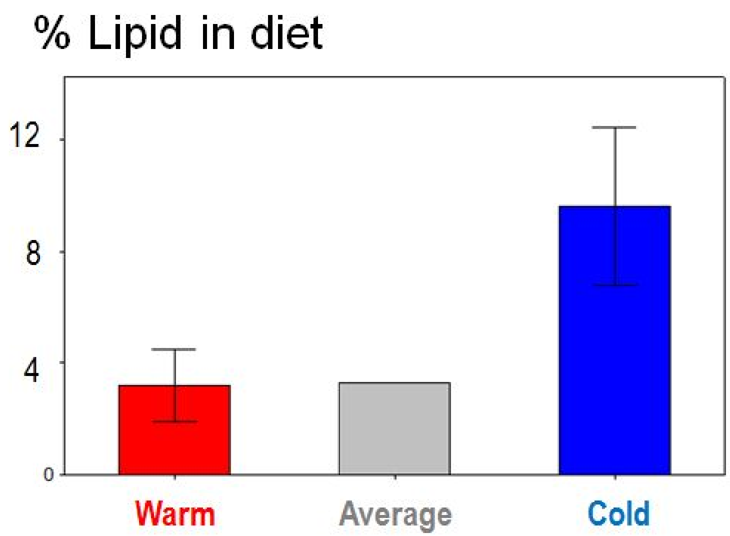
Campbell, Lessard, Ashjian, Durbin, Rynearson, Casas

Copepods and krill are more abundant in cold years: This contradicted our expectation (strike 1!)

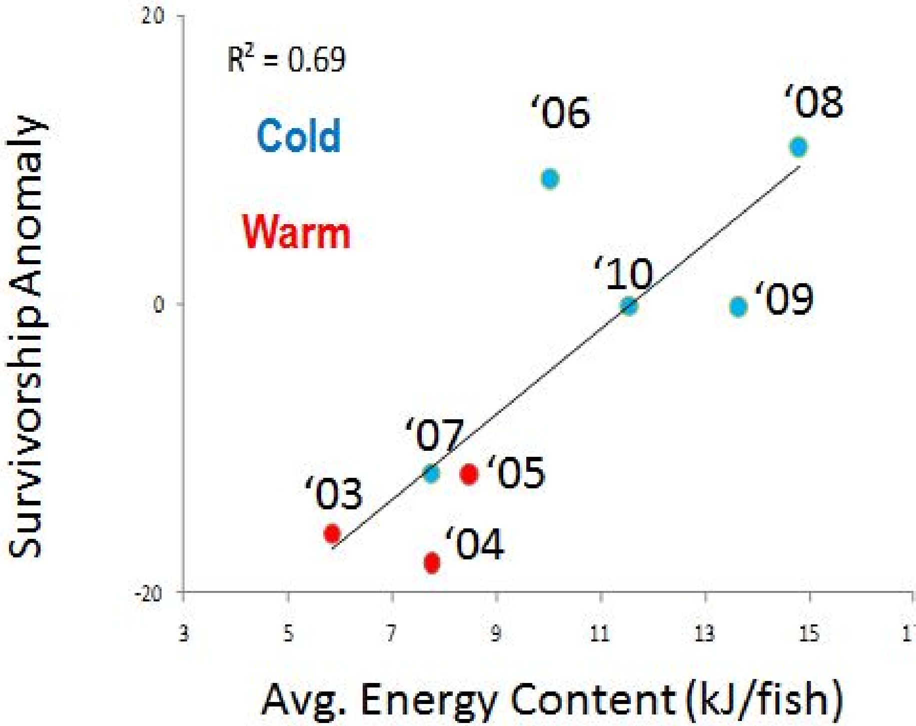


Eisner et al.

As a consequence, age-0 pollock consume richer diets in cold years, better preparing them for their first winter...



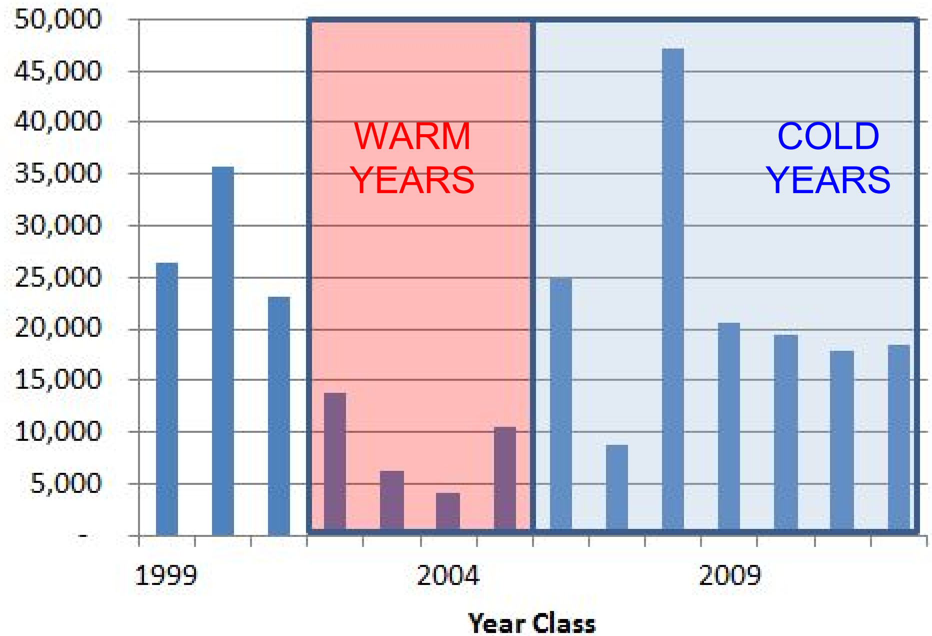
… and enhancing survivorship.



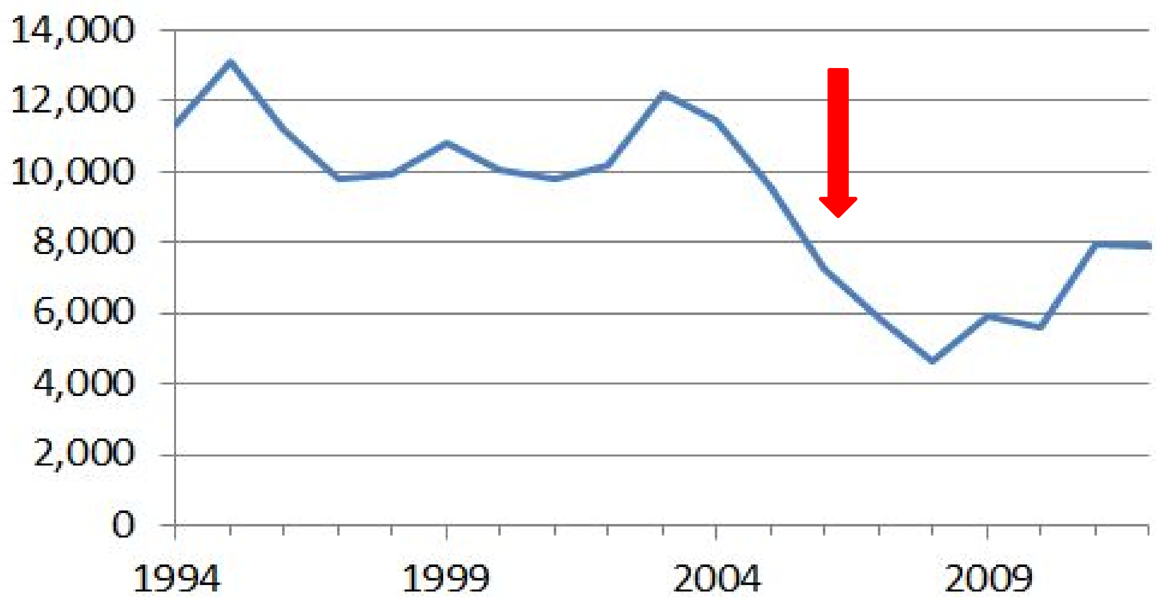
Heintz et al.

EXPLANATION:
Due to bloom timing, large crustacean zooplankton benefit from icy winters, providing prey for age-0 pollock to enter their first winter fat (and happy?)

Age-1 number (millions)

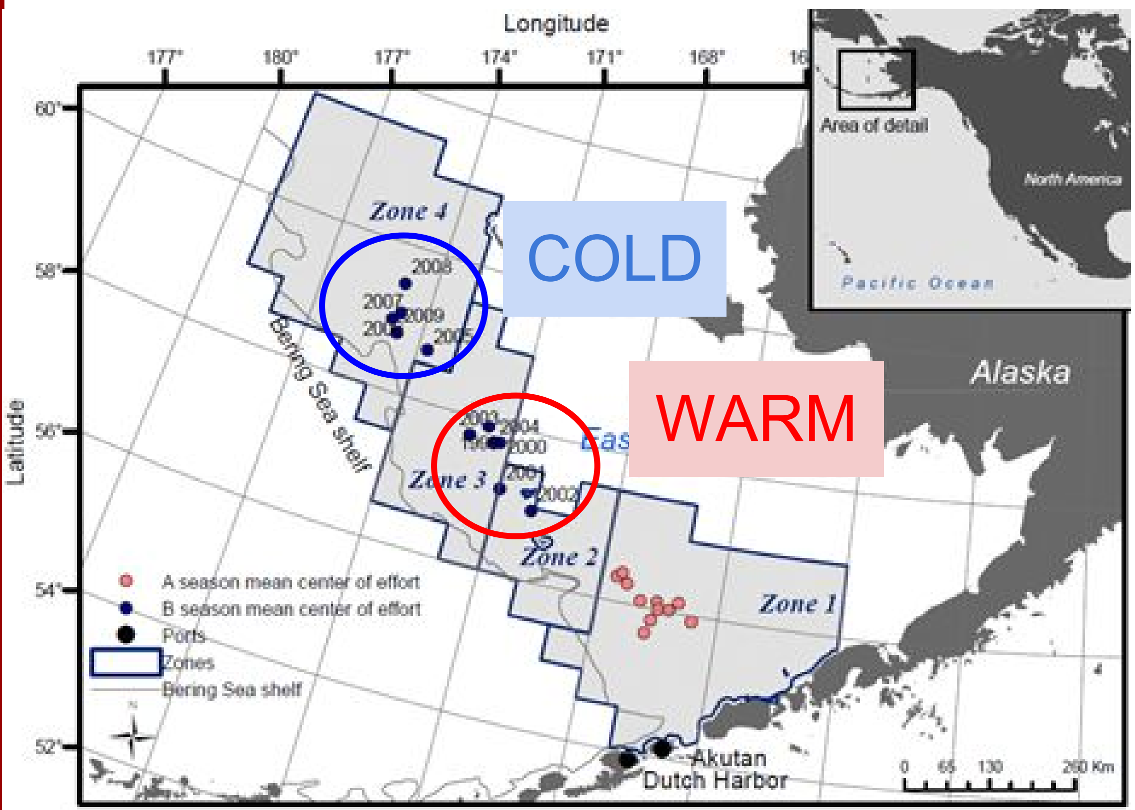


Age-3+
Biomass
(thousands t)



Chapter 2: Location matters for fur seals and fishermen

We predicted fishermen would travel farther north in warm years, but instead the opposite occurred (strike 2!)

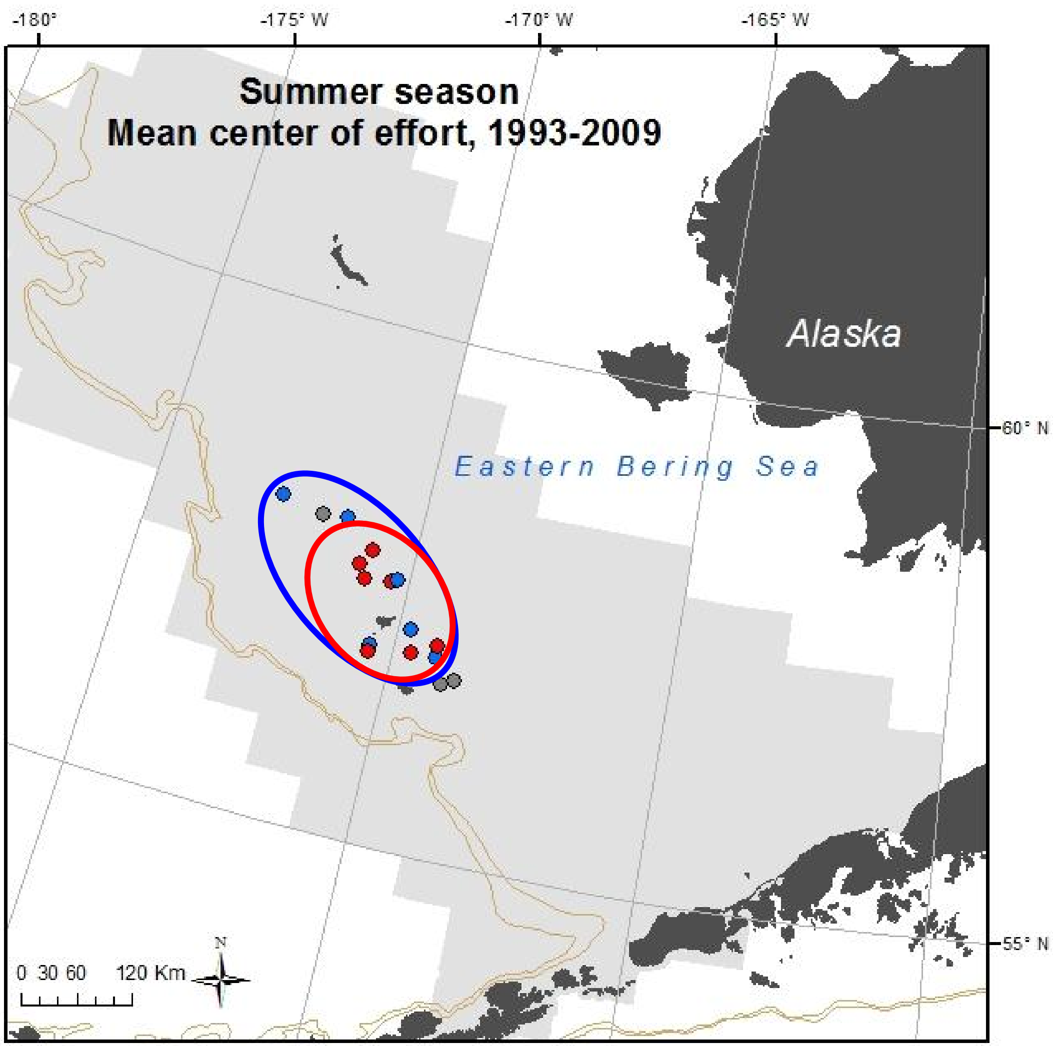


Pollock catcher/processor fleet, center of fishing effort:

In summer, a northward and off-shelf shift correlated with colder conditions and larger cold pool

Haynie, Pfeiffer

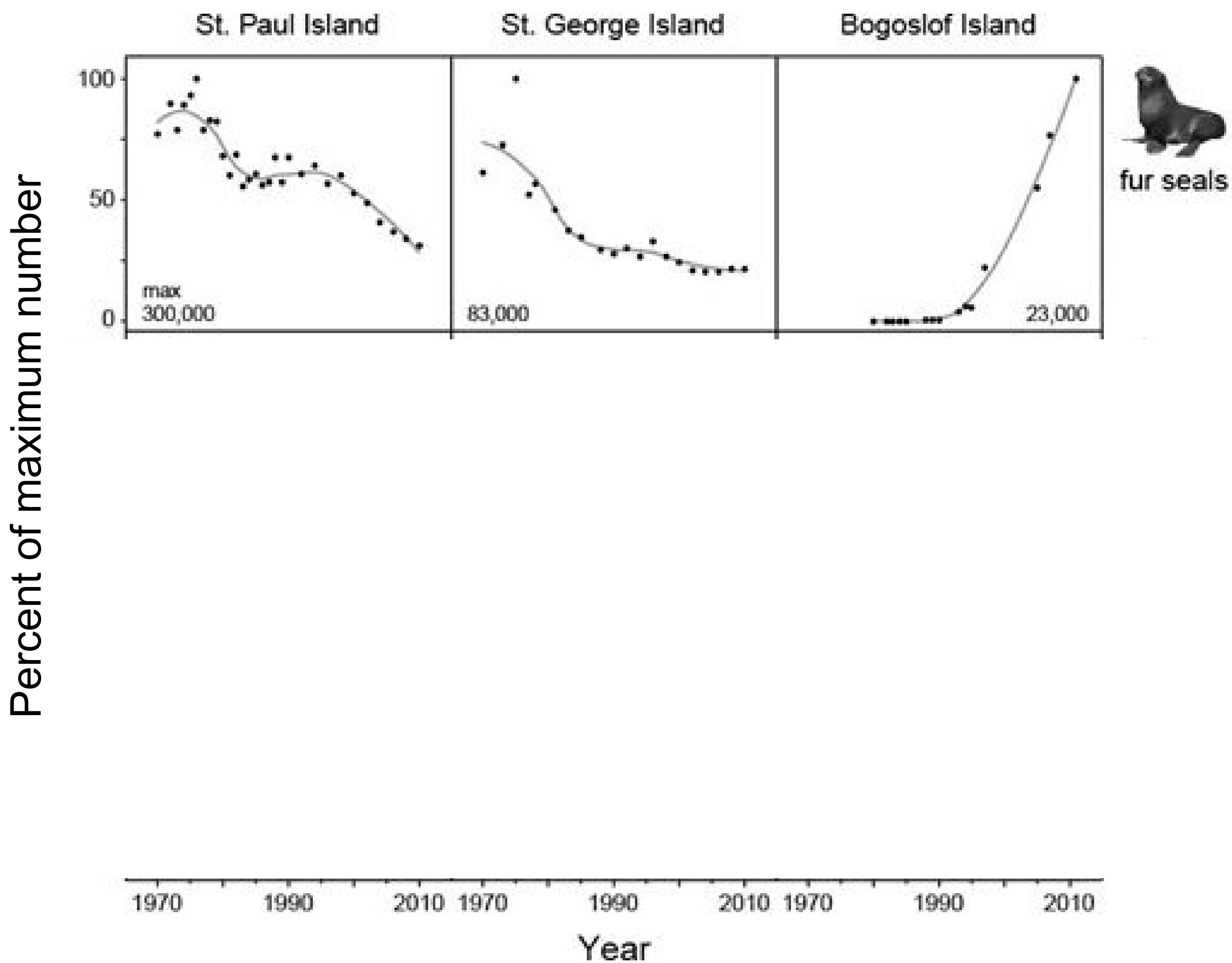
Even with negligible temperature-related shift, some cost effects can occur



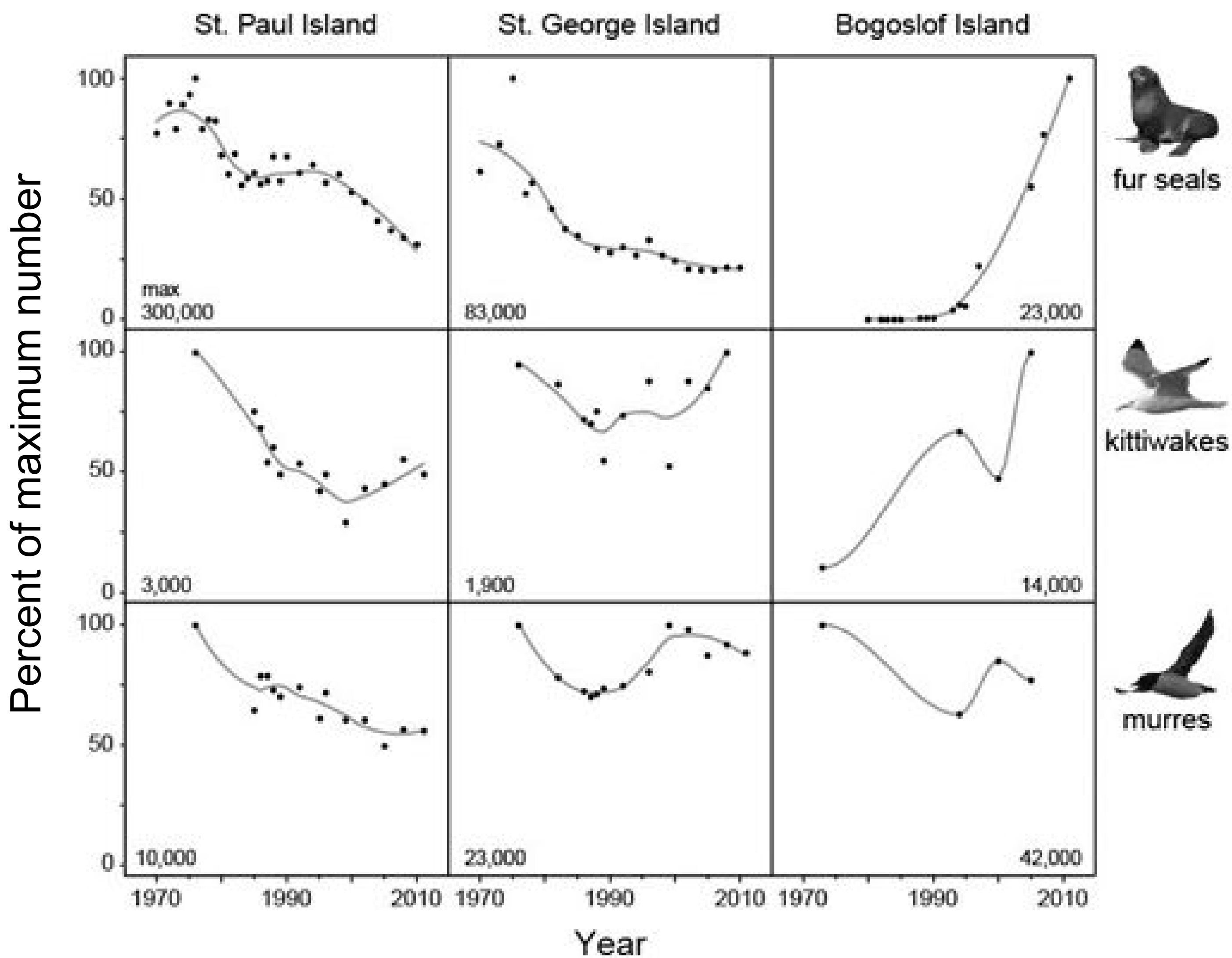
Summer/fall cod longline fishery: Vessels traveled farther (29 vs 20 km/ton catch) and set their gear more often during a trip (39 vs 33) in warm vs. cold years.

Haynie, Pfeiffer

Population trends differ among locations



Population trends differ among locations



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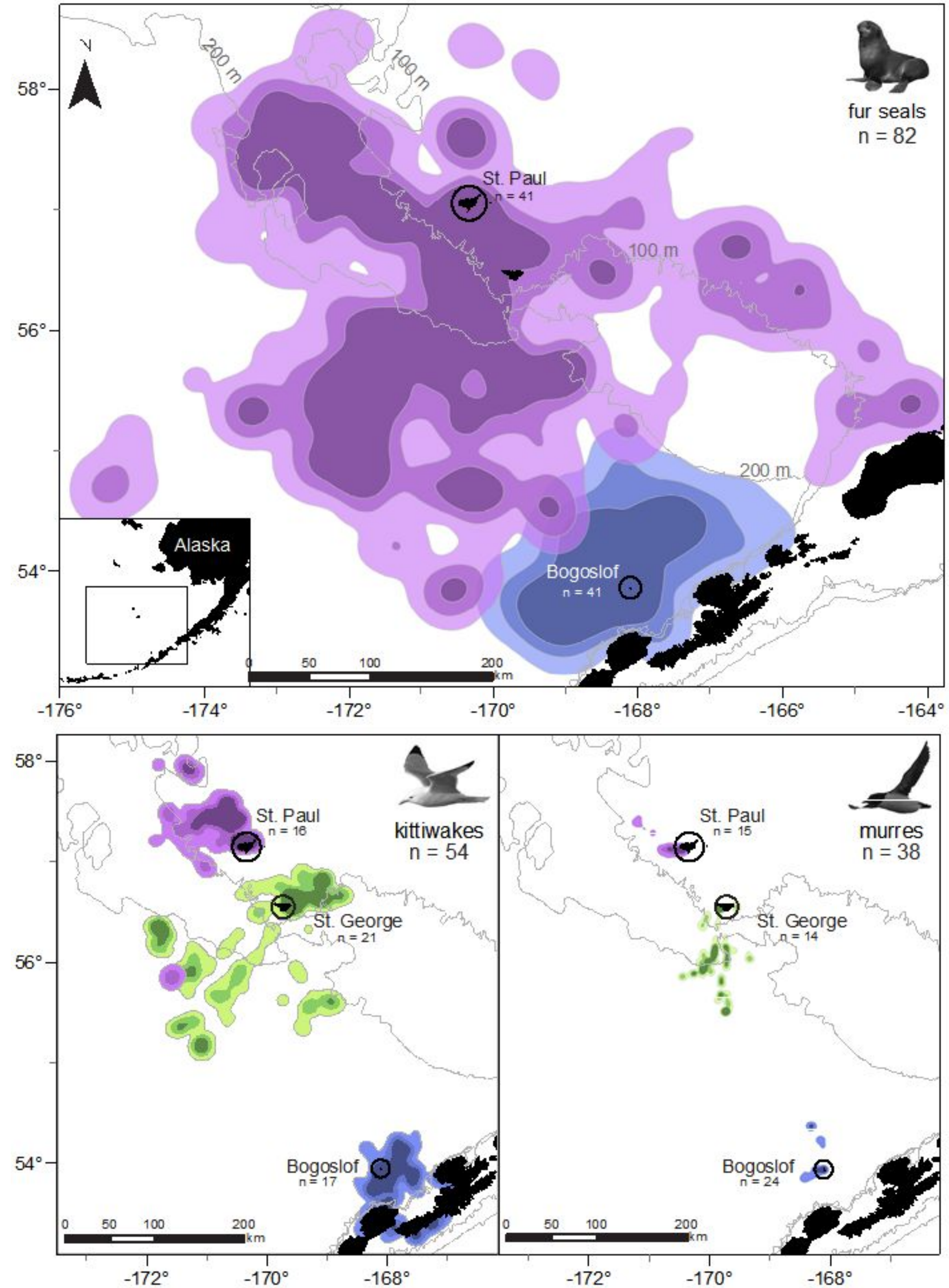
Foraging locations - closer to home is better

- Trip lengths shorter for fur seals and murres at Bogoslof than Pribilofs
- Energy content of diet lower at Pribilofs than Bogoslof because of species consumed

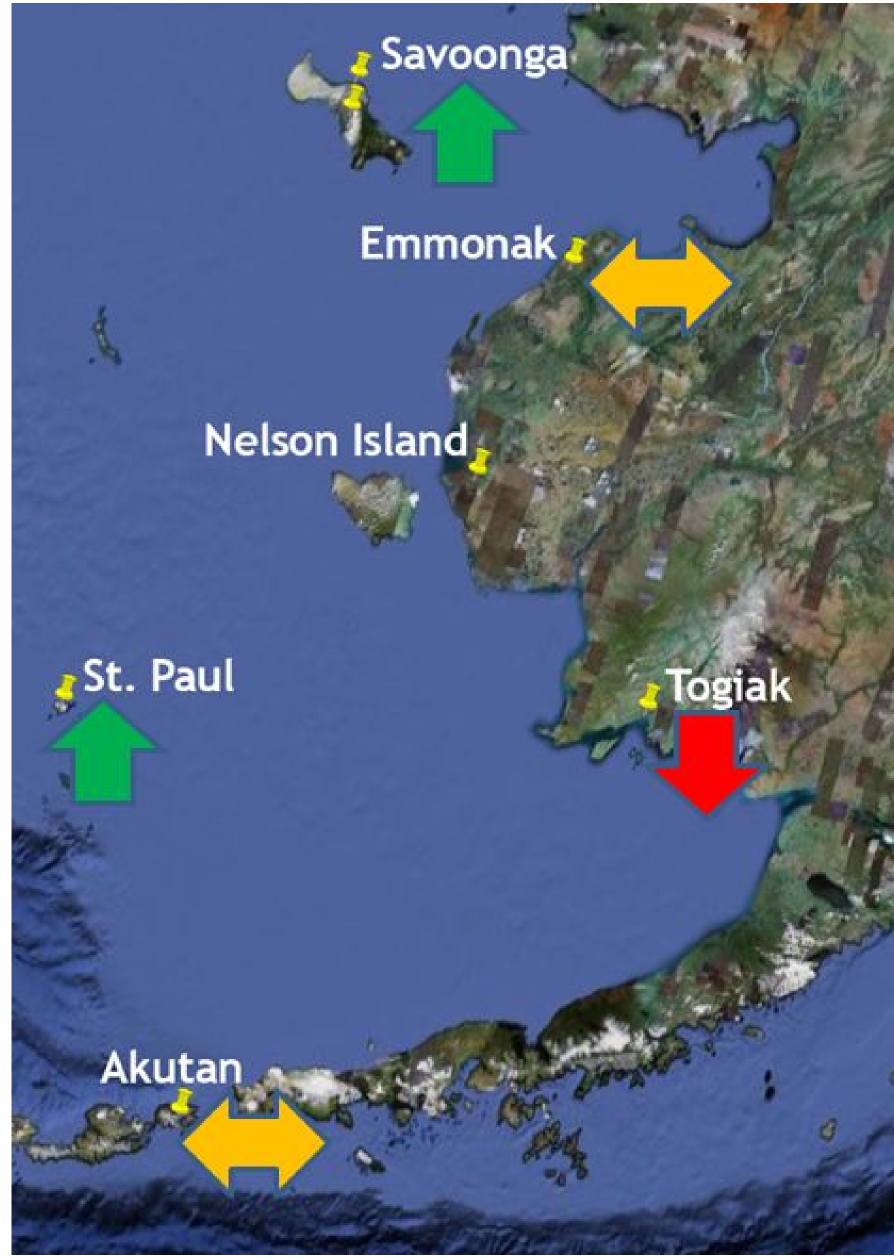
Trites, Battaile, Benoit-Bird, Harding, Heppell, Irons, Kitaysky, Kuletz, Paredes, Renner, Roby



Kernel density use estimates for northern fur seals, blacklegged kittiwakes, and thickbilled murres tagged on St. Paul Island (purple), St. George Island (green) and Bogoslof Island (blue) in 2009. Isopleths are 50, 75, and 95 % use contours with darker colors indicating higher use areas.

Trends observed by communities (local and traditional knowledge, subsistence harvests):

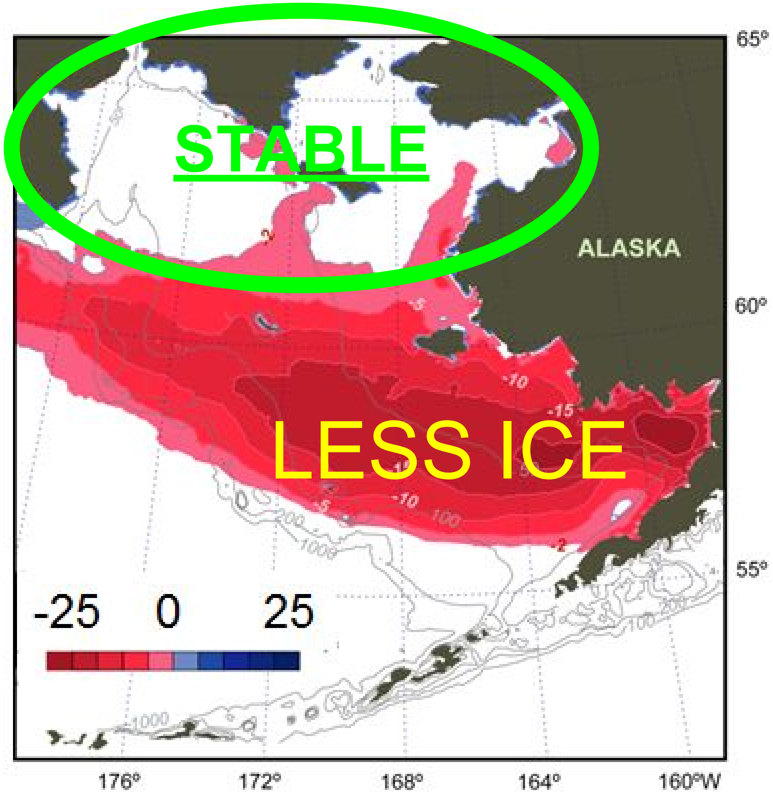
- Location differences between the south (many species in decline) and the north (a productive ecosystem)
- Patterns are consistent with the northern Bering Sea remaining icy during winter and spring and the southeastern Bering Sea more affected by changes in sea ice extent



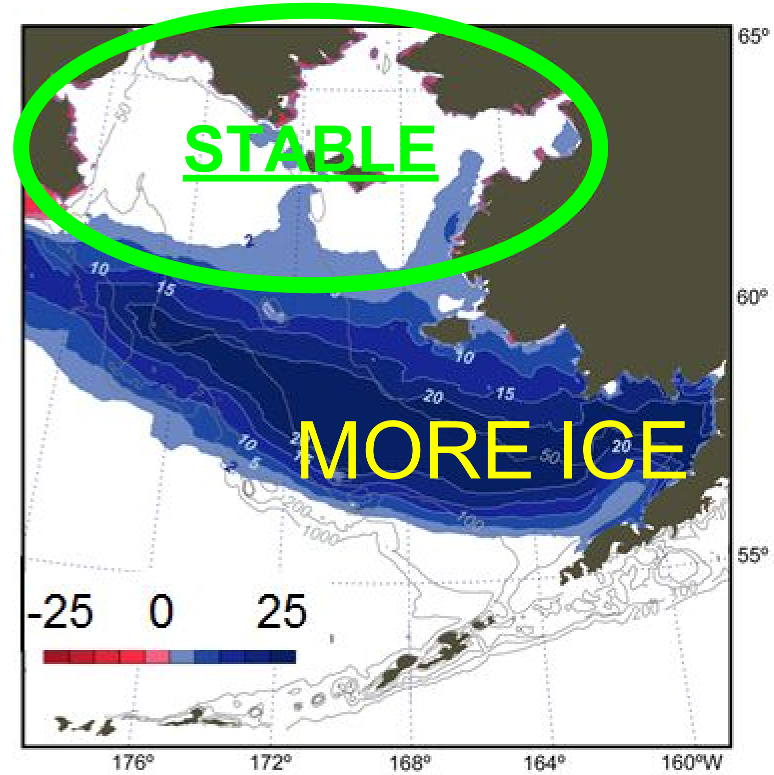
Huntington, Braem, Brown, Hunn, Krieg, Lestenkof, Noongwook, Sepez, Sigler, Wiese, Zavadil

Future ocean conditions: The north will remain cold and dark

Warm years



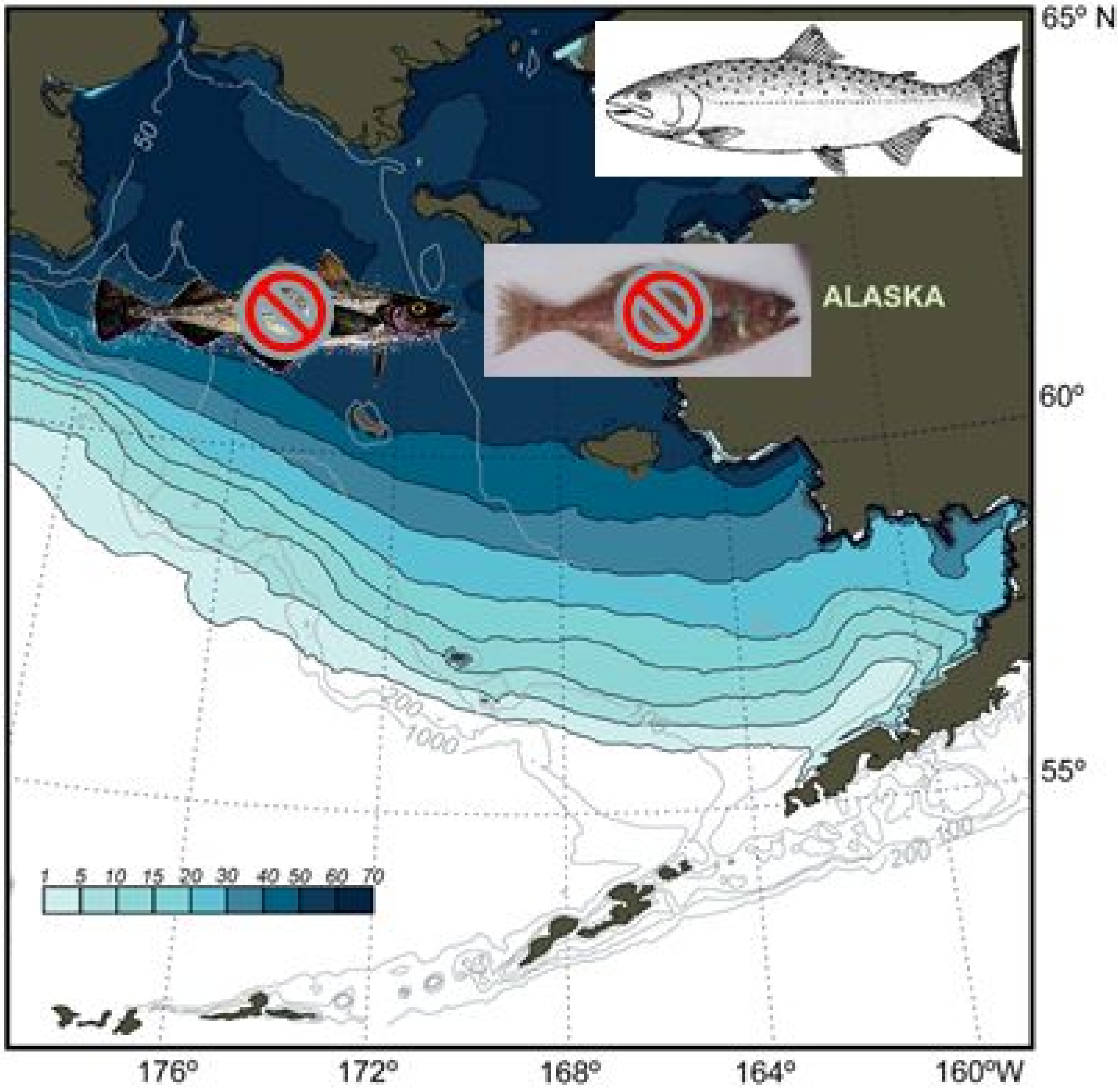
Cold years



The anomalies of sea-ice coverage during March and April during warm years (2001-2005, left) and cold years (2007-2010, right) (Stabeno, Farley, Kachel, Moore, Mordy, Napp, Overland, Pinchuk, Sigler)

Chapter 3: The eastern Bering Sea in the future

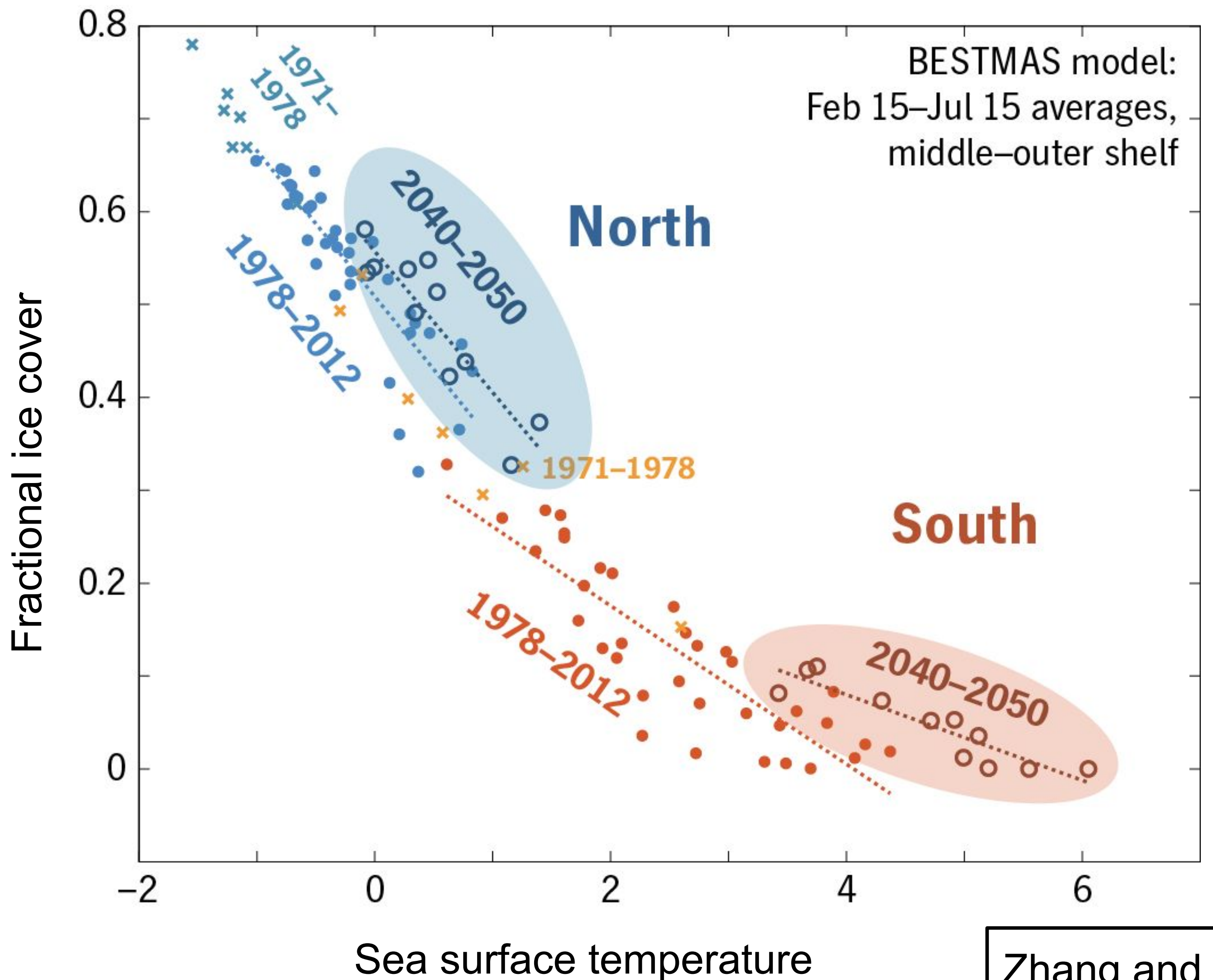
Subarctic fish will not expand into the northern Bering Sea shelf, which contradicts our expectation when the program started (strike 3!)



The average number of days in which sea-ice was present in March and April during 2001-2010.

Stabeno, Farley, Kachel, Moore, Mordy, Napp, Overland, Pinchuk, Sigler, Hollowed, Barbeaux, Cokelet, Kotwicki, Ressler, Spital, Wilson

Models also forecast that the north will remain cold and dark



Zhang and Banas

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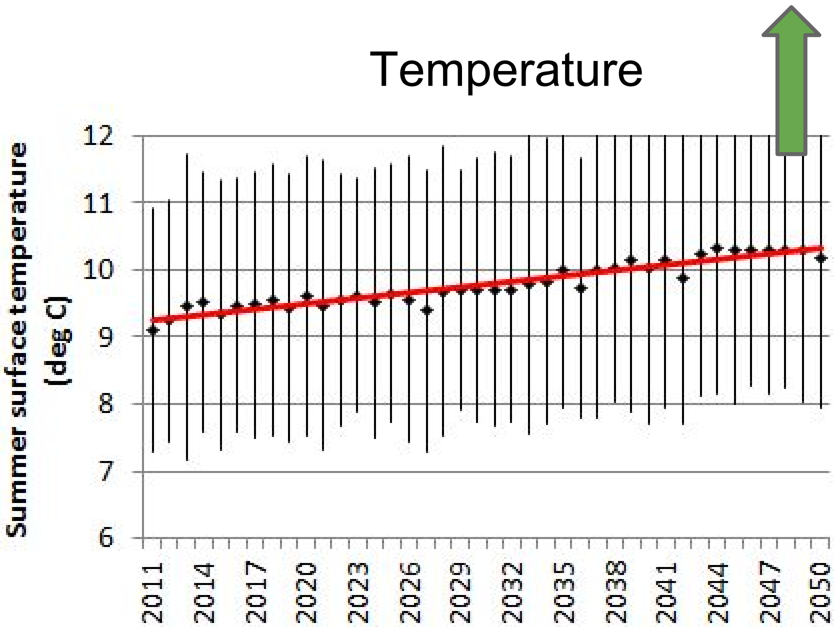
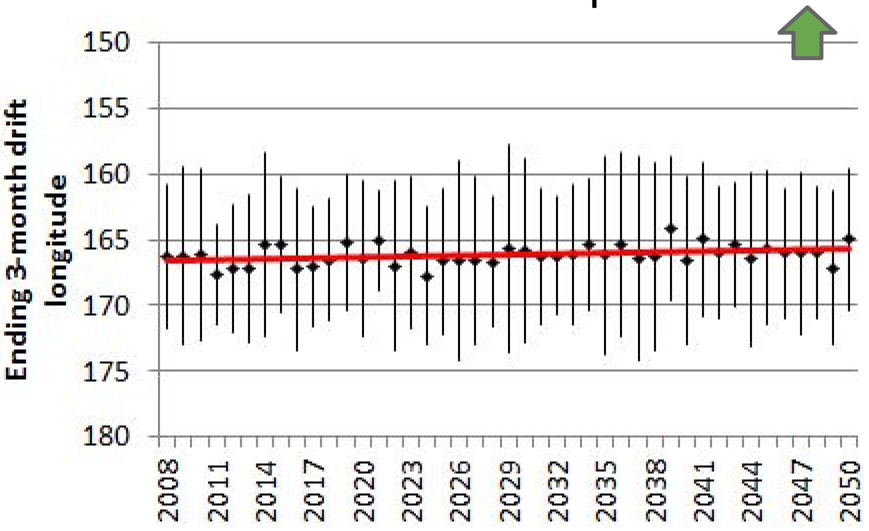
Forecast fish abundance, climate effects differ

Temperature



Inshore transport



Mueter, Bond, Ianelli, Hollowed

Wilderbuer, Stockhausen, Bond

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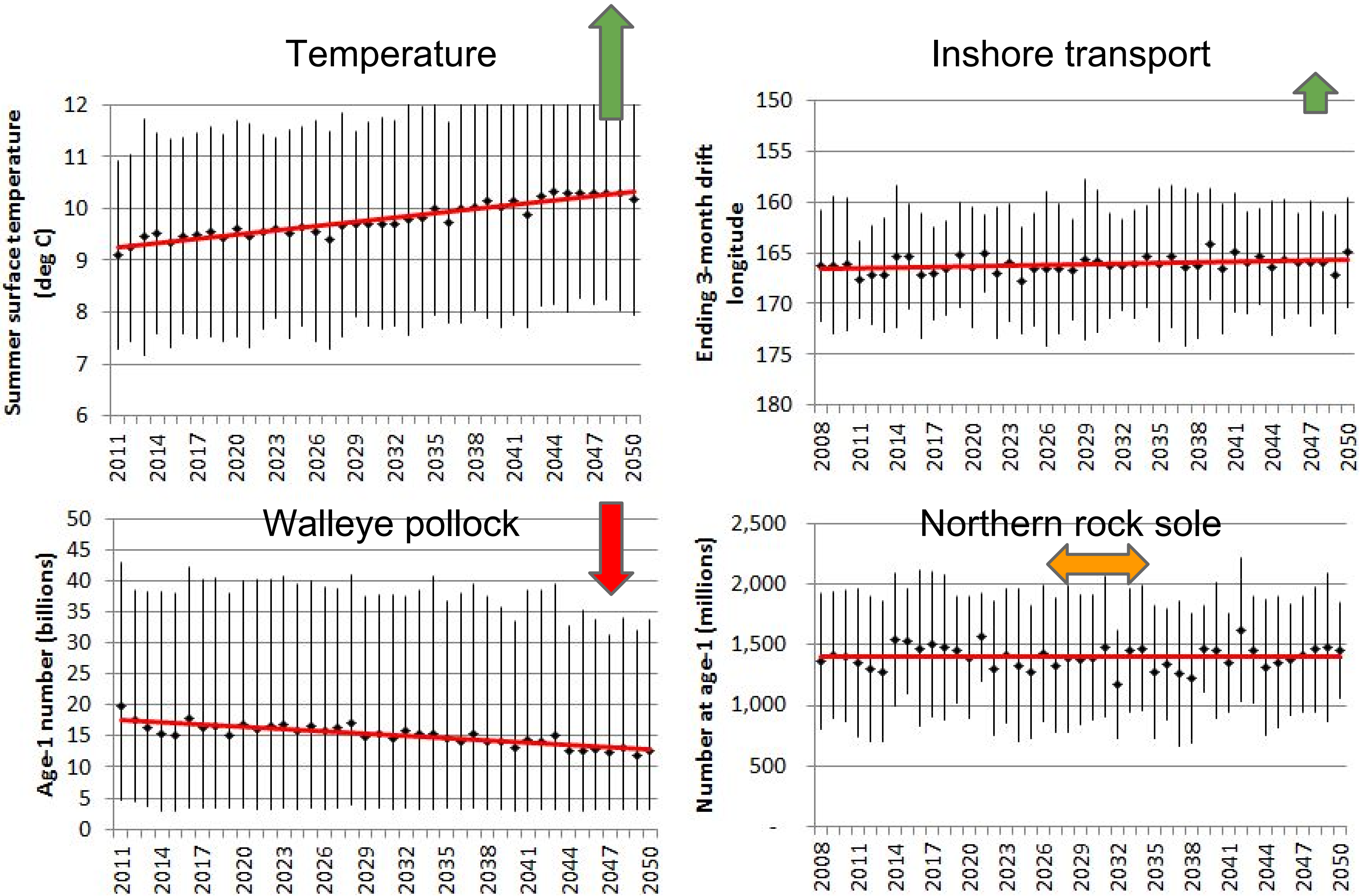

Mueter, Bond, Ianelli, Hollowed

Wilderbuer, Stockhausen, Bond

The benefits of an integrated ecosystem research program (strengths, challenges, solutions)

- Management implications
  - understanding “why” helps stakeholders
- Deep and broad publication set
- Formation of new teams and collaborations
- Results achieved by this integrated program that likely would not have been accomplished by a series of individual projects (3 examples)

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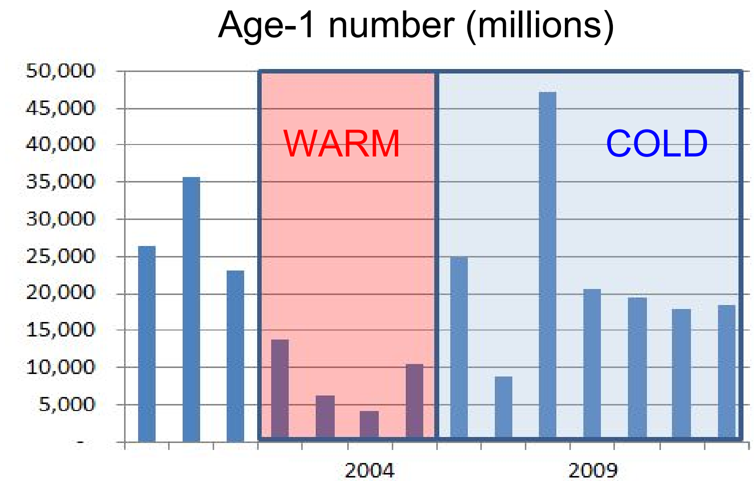
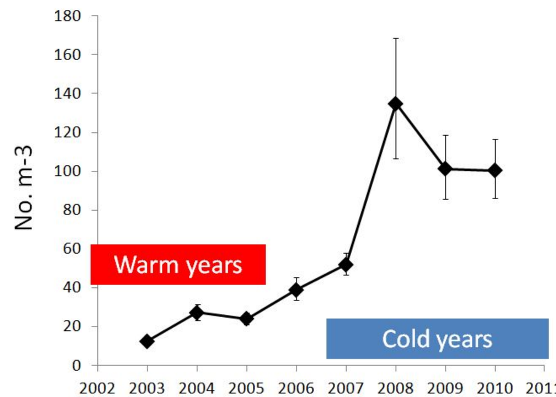
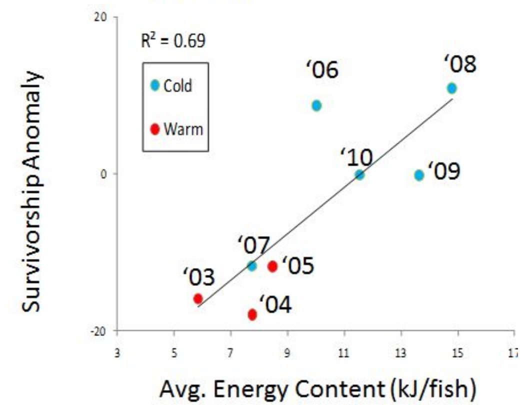
Due to bloom timing, large crustacean zooplankton benefit from icy winters, providing prey for age-0 pollock to enter their first winter fat







COLD YEAR

Low energy demand

ICE

Andrews, Ashjian, Baier, Banas, Bluhm, Campbell, Casas, Cieciel, Cokelet, Coyle, Durbin, Eisner, Farley, Gann, Gibson, Gradinger, Heintz, Hunt, Iken, Janout, Kachel, Ladd, Lessard, Liu, Lomas, Menzia, Moore, Moran, Mordy, Mueter, Napp, Overland, Pinchuk, Proctor, Ressler, Rynearson, Salo, Siddon, Sigler, Stabeno, Weems, Wisegarver, Yamaguchi, Zeeman, Zerbini, Zhai, Zhang

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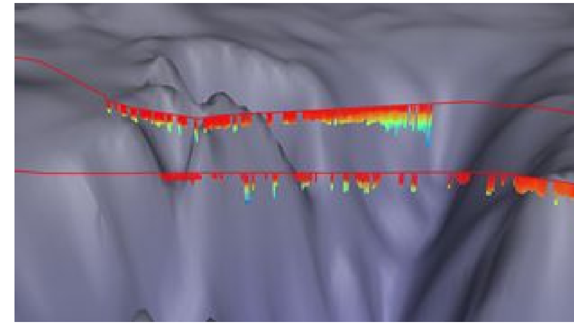
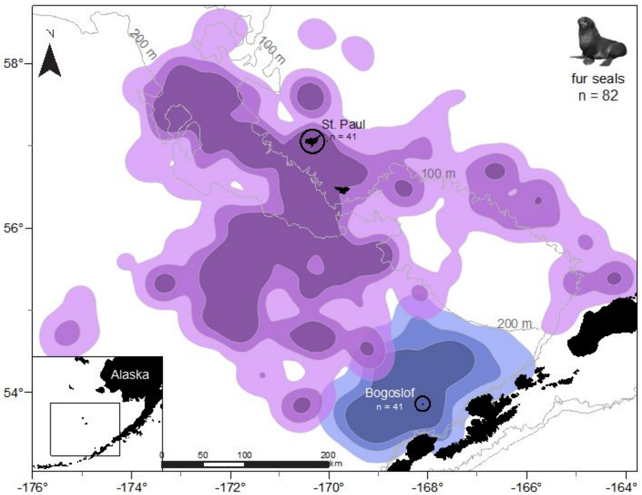
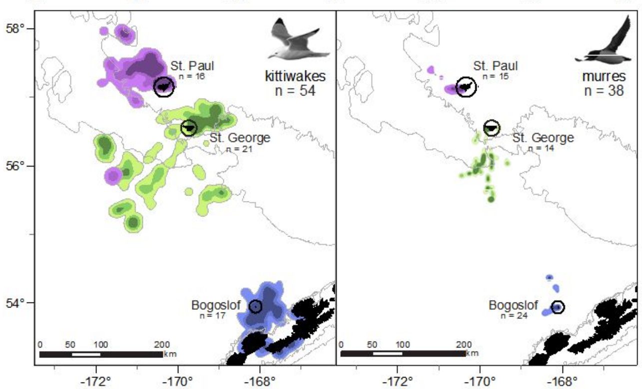
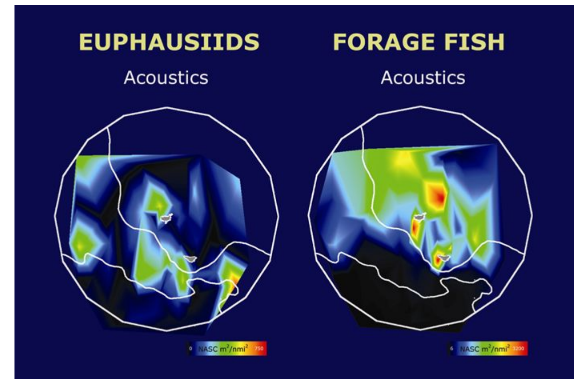
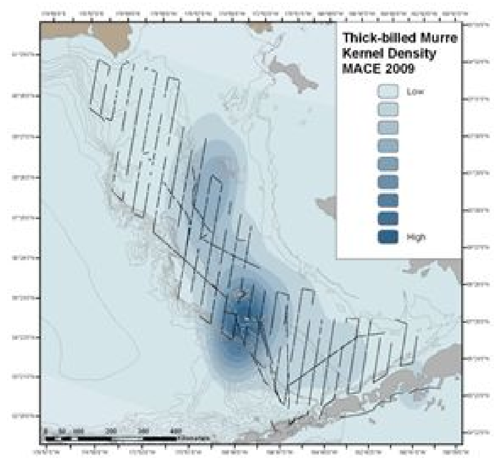
Prey closer to colonies and more energy dense at Bogoslof compared to Pribilof islands

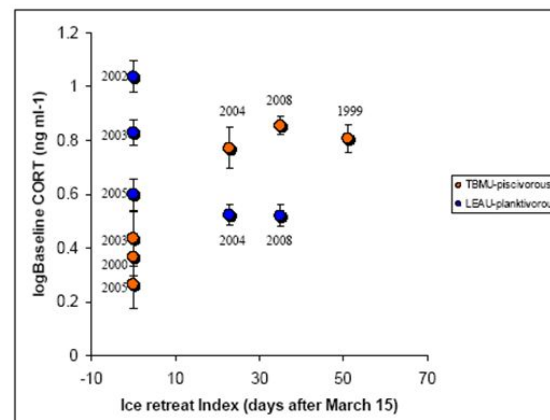












Trites, Battaile, Benoit-Bird, Friday, Harding, Heppell, Hoover, Irons, Jones, Kitaysky, Kuletz, McIntosh, Mueter, Nordstrom, Orben, Paredes, Renner, Ressler, Roby, Sigler, Suryan, Waluk, Wilson, Young, Zerbini

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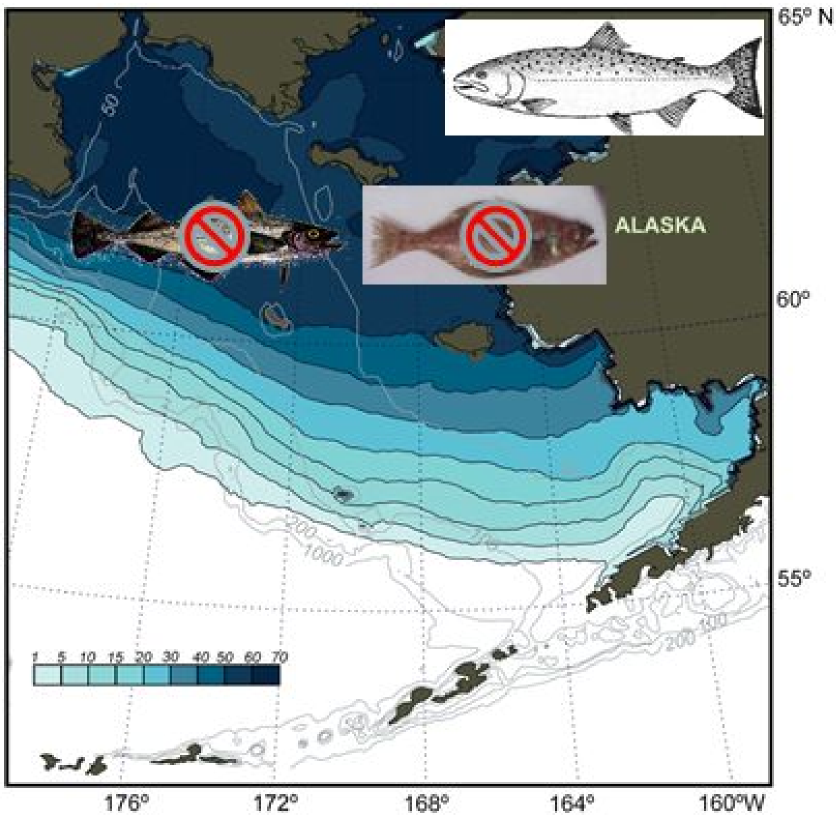
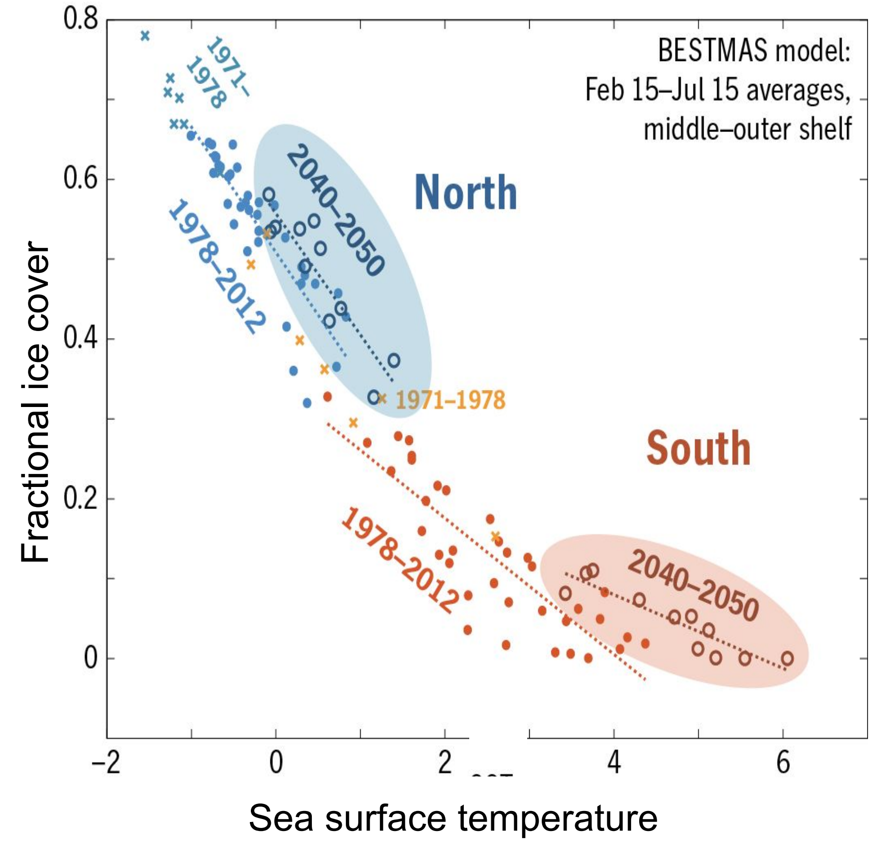
The northern Bering Sea will stay cold for the foreseeable future and subarctic fish will not expand into there

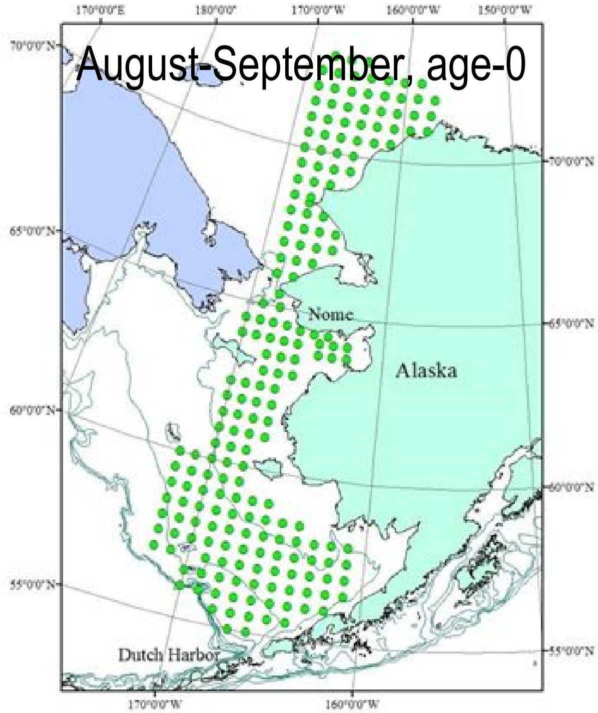


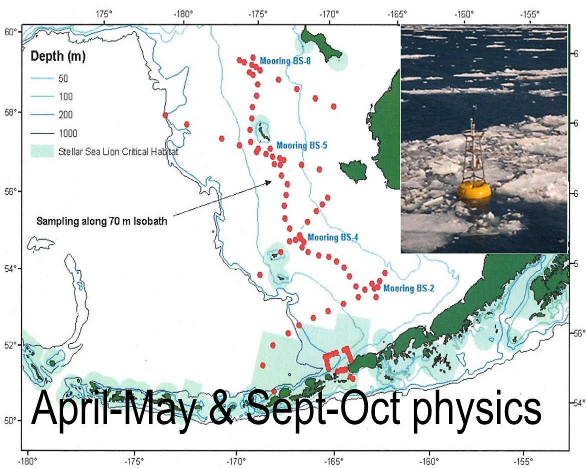


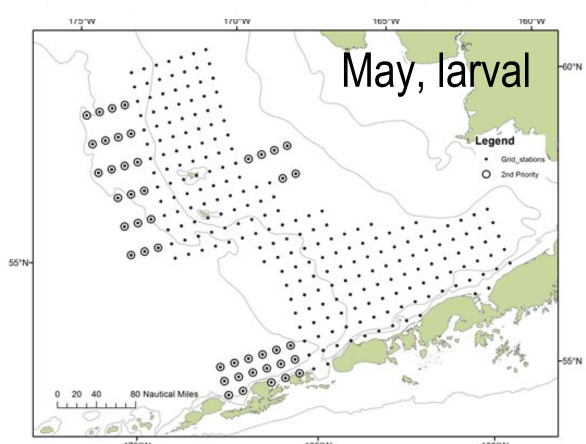
Banas, Barbeaux, Bond, Cokelet, Curchitser, Farley, Gibson, Hedstrom, Hermann, Hollowed, Kachel, Kotwicki, Moore, Mordy, Napp, Overland, Pinchuk, Ressler, Sigler, Spital, Stabeno, Wilson, Zhang

Context for the Bering Sea Project

Built upon previous FOCI and BASIS research







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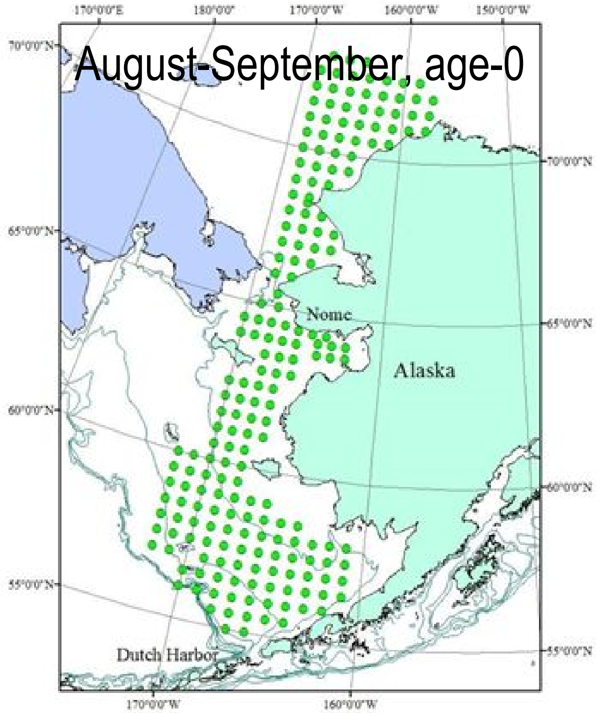
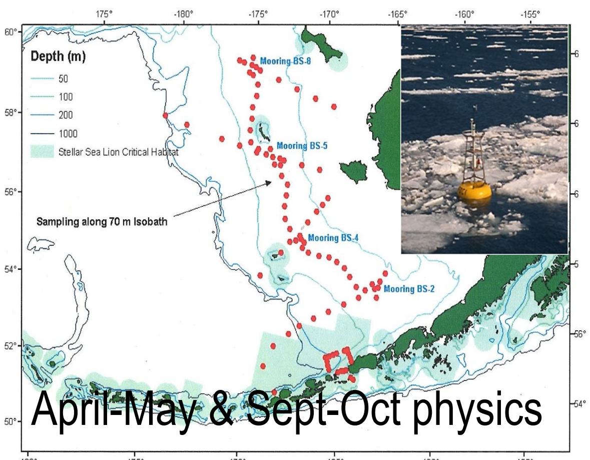
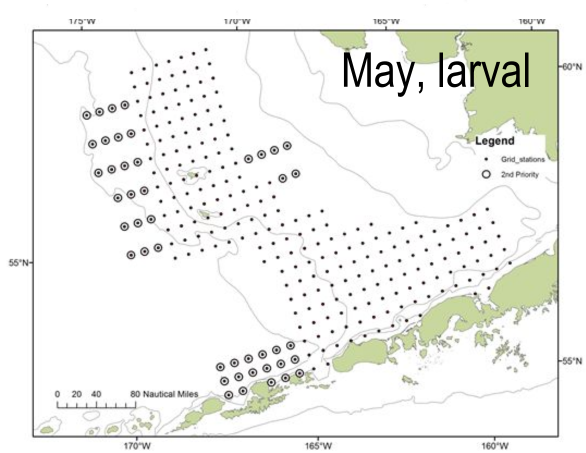
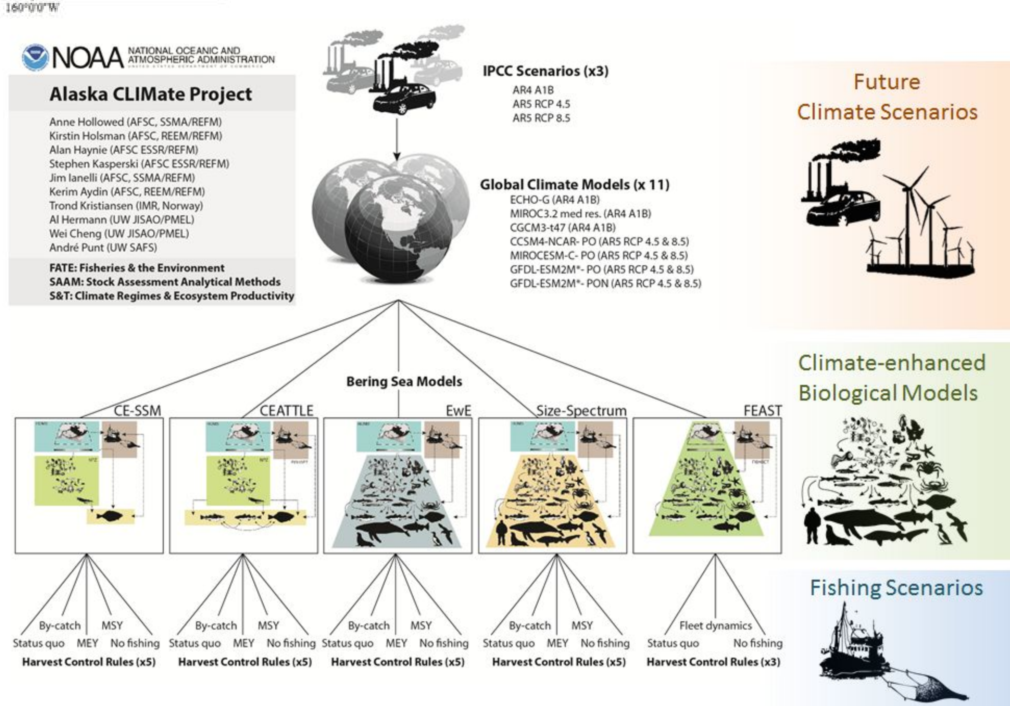






Continuing as RPA and ACLIM



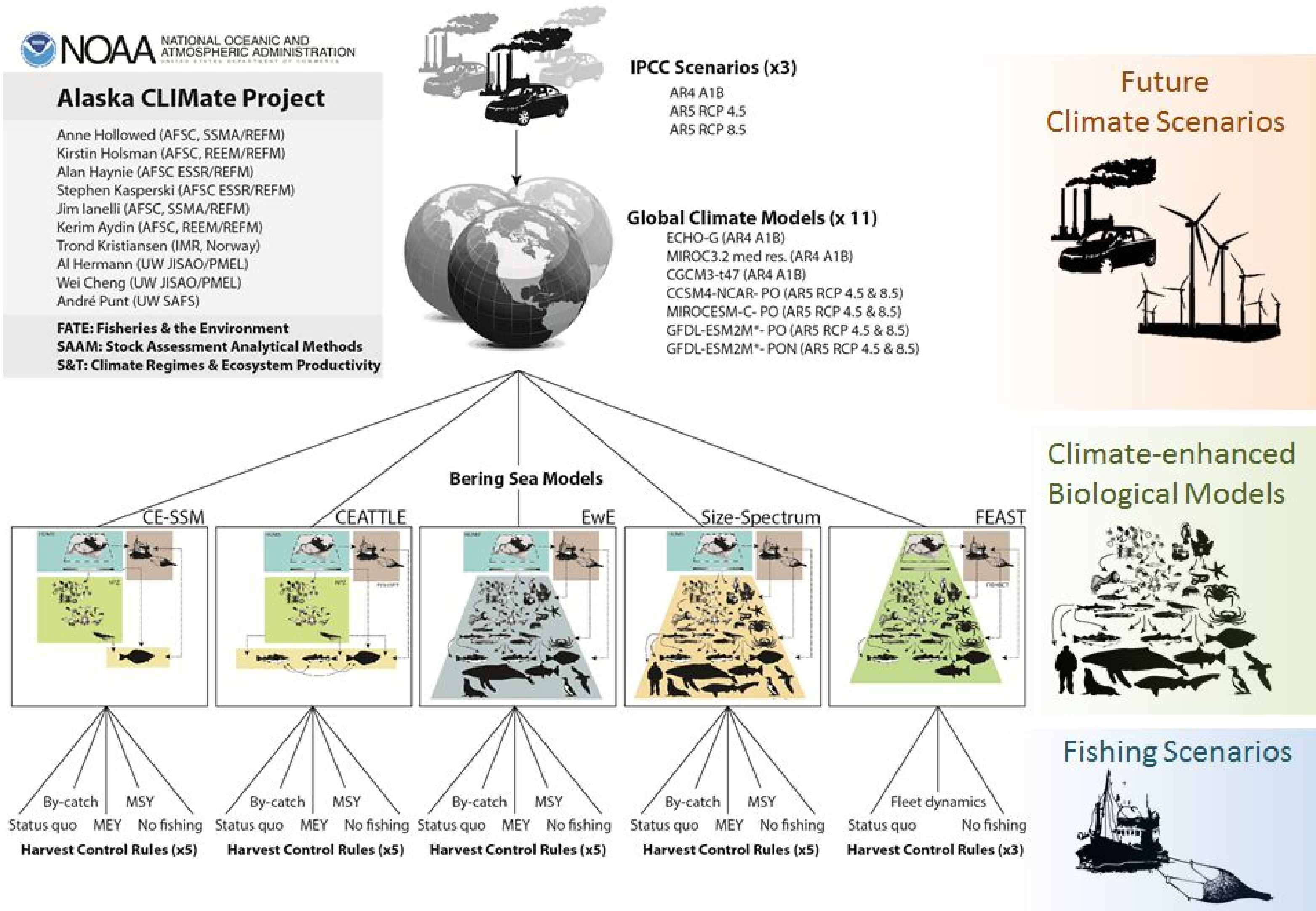
Status of ecosystem data (TOR 4)

- Bering Sea Project Archive

Strategies to obtain and manage ecosystem data

- Hypotheses
- Study plan

Status of ecosystem modeling (TOR 5)



Integrated ecosystem-level analyses

- Climate and oceanography (Stabeno et al., 2012a, b)
- Bloom timing, zooplankton, and juvenile walleye pollock (Hunt et al., 2011)
- Zooplankton and juvenile walleye pollock (Coyle et al., 2011)
- Walleye pollock bioenergetics (Heintz et al., 2013)
- Climate, sea ice, phytoplankton, zooplankton, and juvenile walleye pollock (Sigler et al., 2016)
- Prey patch and top-level predator foraging (Benoit-Bird et al., 2013)
- Climate and communities (Huntington et al., 2013)

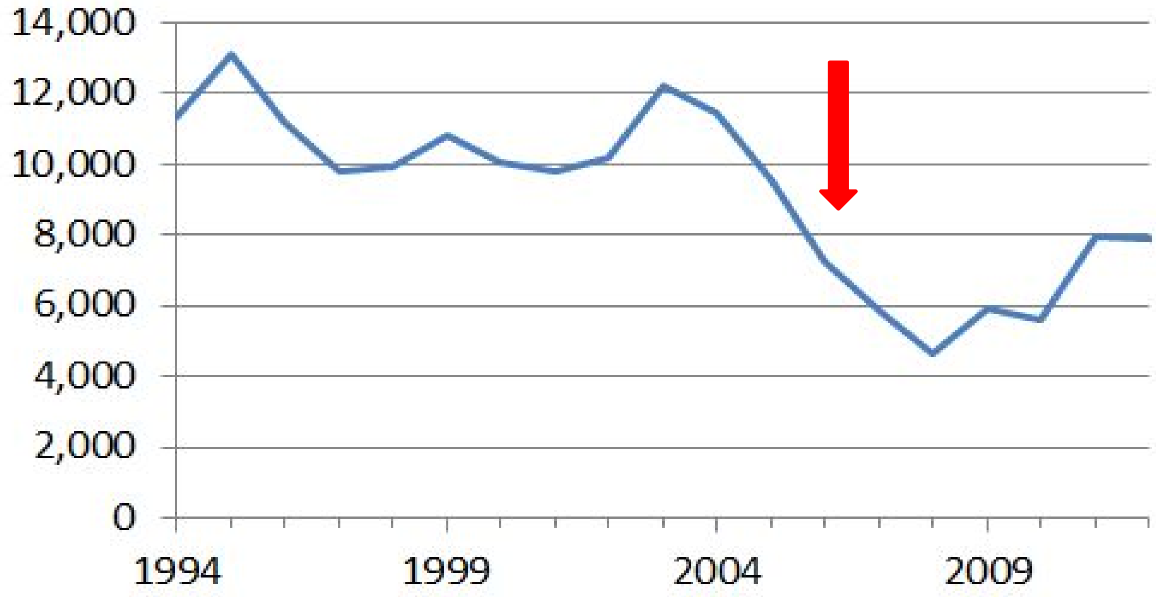
Cumulative analyses

Quantitative climate and fisheries effects

- Walleye pollock (Mueter et al., 2011)
- Northern rock sole (Wilderbuer et al., 2013)
- Red king crab (Punt et al., 2014)
- Tanner crab (Punt et al., 2015)

Inclusion of ecosystem data into living marine resource management advice (TOR 6)

Age-3+ Biomass (thousands t)



Provides understanding for why abundance has declined and catch quotas should be reduced.

How was this inclusion decided?

- This information was presented during the annual stock assessment cycle
- Reviewed by Groundfish Plan Team and Scientific and Statistical Committee
- Presented to North Pacific Fisheries Management Council

Peer-review of ecosystem-related science program and products (TOR 7)

Nearly 170 peer-reviewed publications to date

Communication to managers, partners, stakeholders and the public (TOR 8)

- Annual presentation at Alaska Marine Science Symposium (audience ~800-1,000 people)
- Two-page briefing papers
- Magazine
- Presentations at North Pacific Fisheries Management Council related meetings, Ocean Sciences, National Science Foundation, Arctic Research Council, etc.